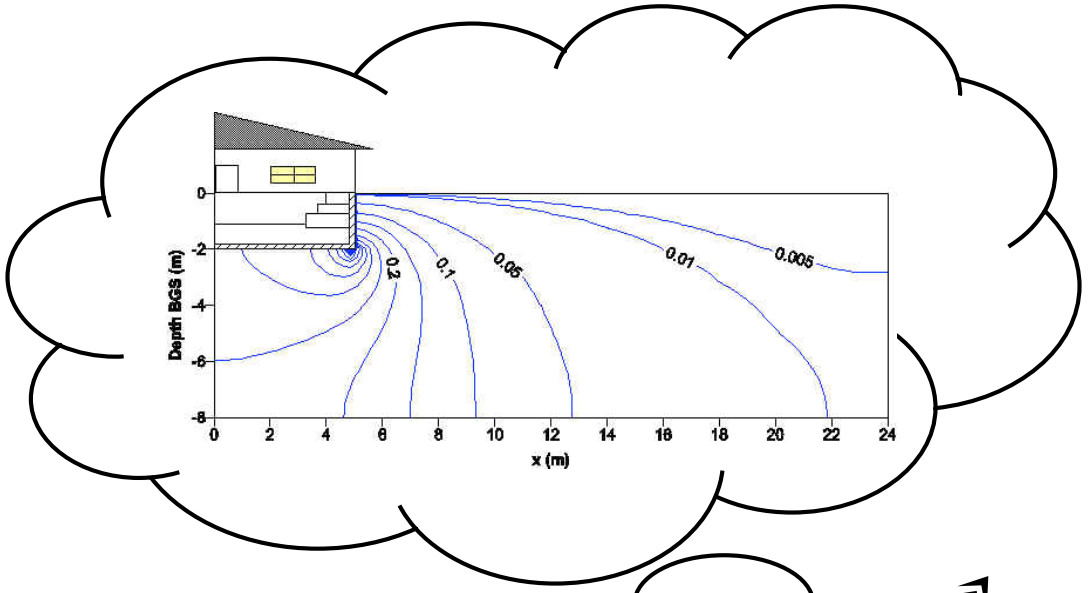
Learning Through the Simulation of Vapor Intrusion Scenarios



Conducted by:

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This work made possible through the generosity of the Exxon-Mobil Foundation

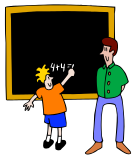
Outline

1. Another model?… Why?… Look where the last one got us… Didn't you learn anything from that experience?
2. Did you really have to create a new code? Can't you configure MODFLOW somehow to run those simulations?
3. Cool pictures - but what was the point you wanted to make?

History and Histrionics…

Johnson and Ettinger (1991 - ?)

[The beginning of the end..]



A Decade of Pain and Suffering…

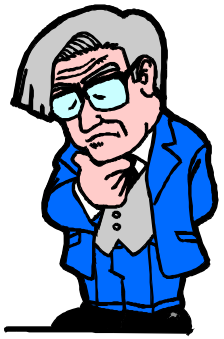
[Maybe it's better off forgotten…]

USEPA OSWER Draft Guidance [2002]

[Maybe this would be better off forgotten too…]

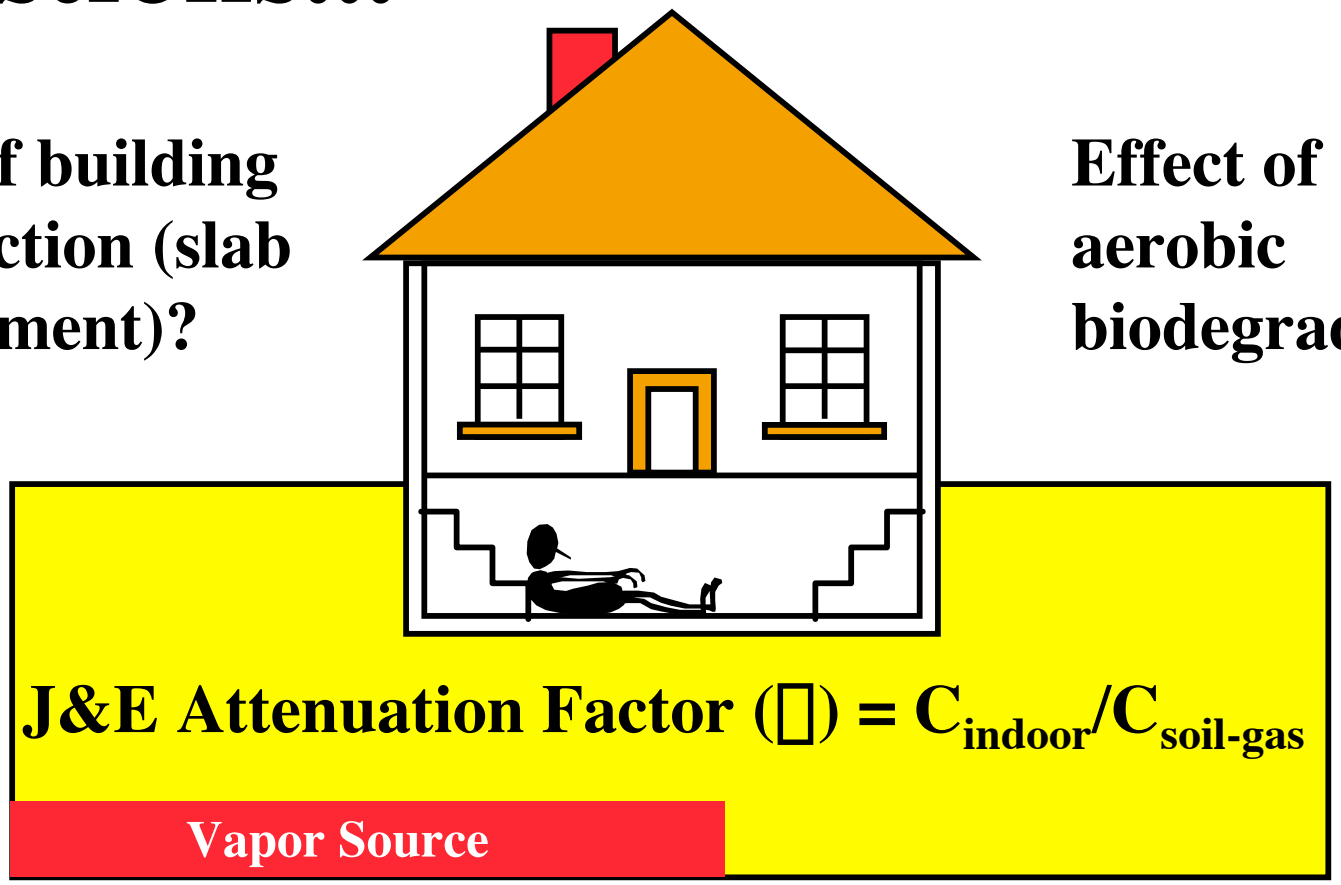
- **There has been some good work, especially in recent years, and**
- **People are becoming more knowledgeable of the technical issues**
- **But the speculation/data ratio is still very high, and**
- **Many myths persist**
- **The USEPA OSWER (2002) guidance reflects this, but it has served as a platform to stimulate discussion on a few key topics --->**

Questions...



Effect of building construction (slab vs. basement)?

Effect of aerobic biodegradation?

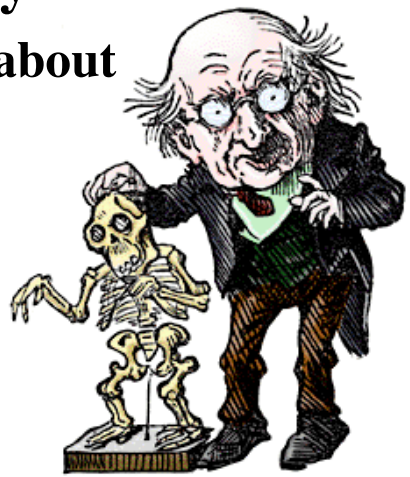


Effect of lateral separation between building and vapor source?

Sub-foundation vs. near-foundation soil gas sampling?

Why Use Numerical Modeling?

1. I'm not getting any younger and, while agencies seem willing to promulgate guidance that will cost the industry millions of dollars (and spawn lawsuits), no one seems willing to invest in the field-based research needed to create the technically-defensible guidance…
2. The Exxon-Mobil Foundation gave me a little money with no strings attached (Thanks Mark! I'm really sorry about that UST talk yesterday..), and I have a very motivated graduate student…
3. Through numerical modeling we can more quickly:
   - study the results from a range of scenarios,
   - identify expected behaviors and their dependence on site-specific characteristics,
   - use this knowledge to design more efficient field studies…

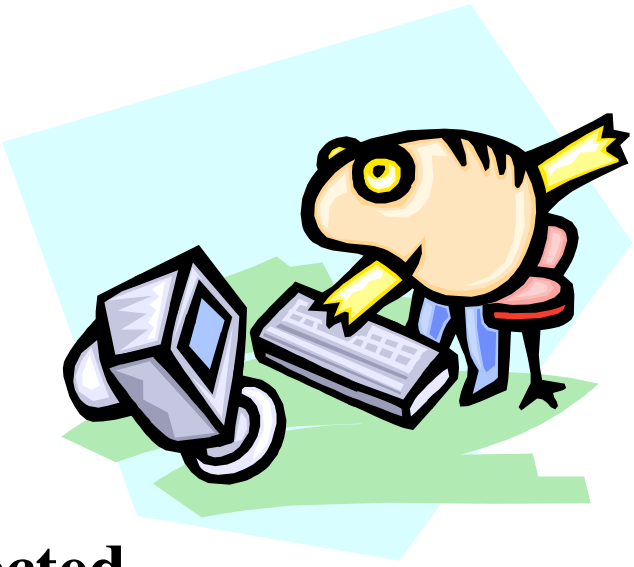


It's Not MODFLOW…

- **It's based on an ugly set of complicated equations full of Greek symbols and derivatives [equations for the air flow pressure field are coupled with contaminant transport/fate equations and complex boundary conditions]**
- **It allows for transient simulations with time-varying building under-pressurization**
- **Multi-component systems are modeled (e.g., O_2, hydrocarbons)**
- **Dual-Monod kinetics (user configurable - no degradation, first-order, etc.)**
- **Variable building construction (basements, slabs, varying crack sizes and crack locations)**
- **Variable source characteristics (location, strength)**
- **Layered subsurface settings**

How does it work?

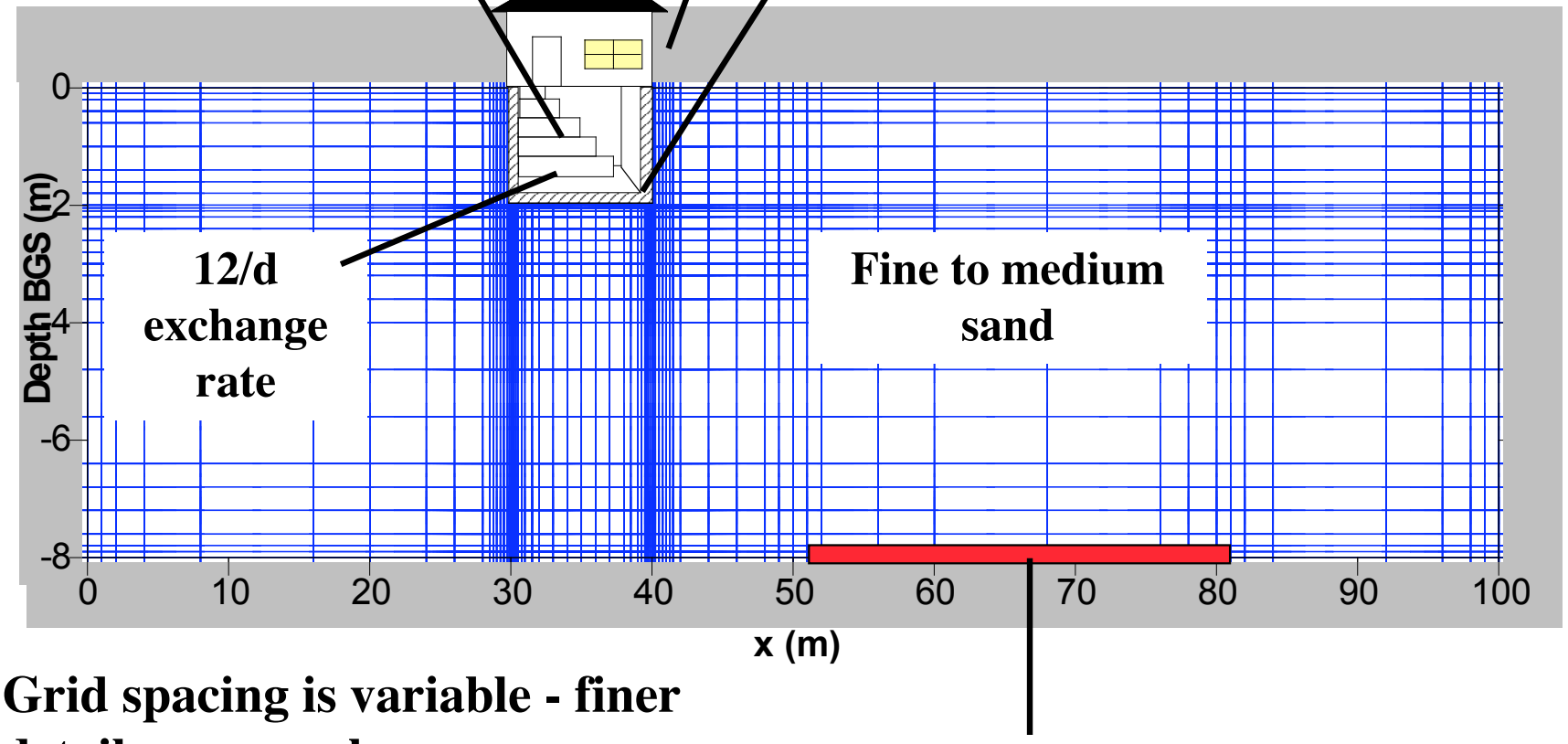
1. You need a graduate student that speaks Portuguese…
2. The problem geometry is defined
3. System properties are assigned (soil properties, building parameters, etc.)
4. A finite-difference grid is assigned
5. Numerical control parameters are selected (starting time-step size)
6. Push the button and wait…. A few hours to a week… (at least that's what Lili says..)
7. Process the output…



How do you know it works?

- **Output compared with numerical solution for pressure field around a building published by Loureiro et al. (Environ. Sci. Technol. 24, 1338-1348, 1990)**
- **Output compared with numerous 1-D steady-state and transient analytical solutions for vapor flow and advective-diffusive transport.**
- **Built-in mass balance checks on air and all chemical species**

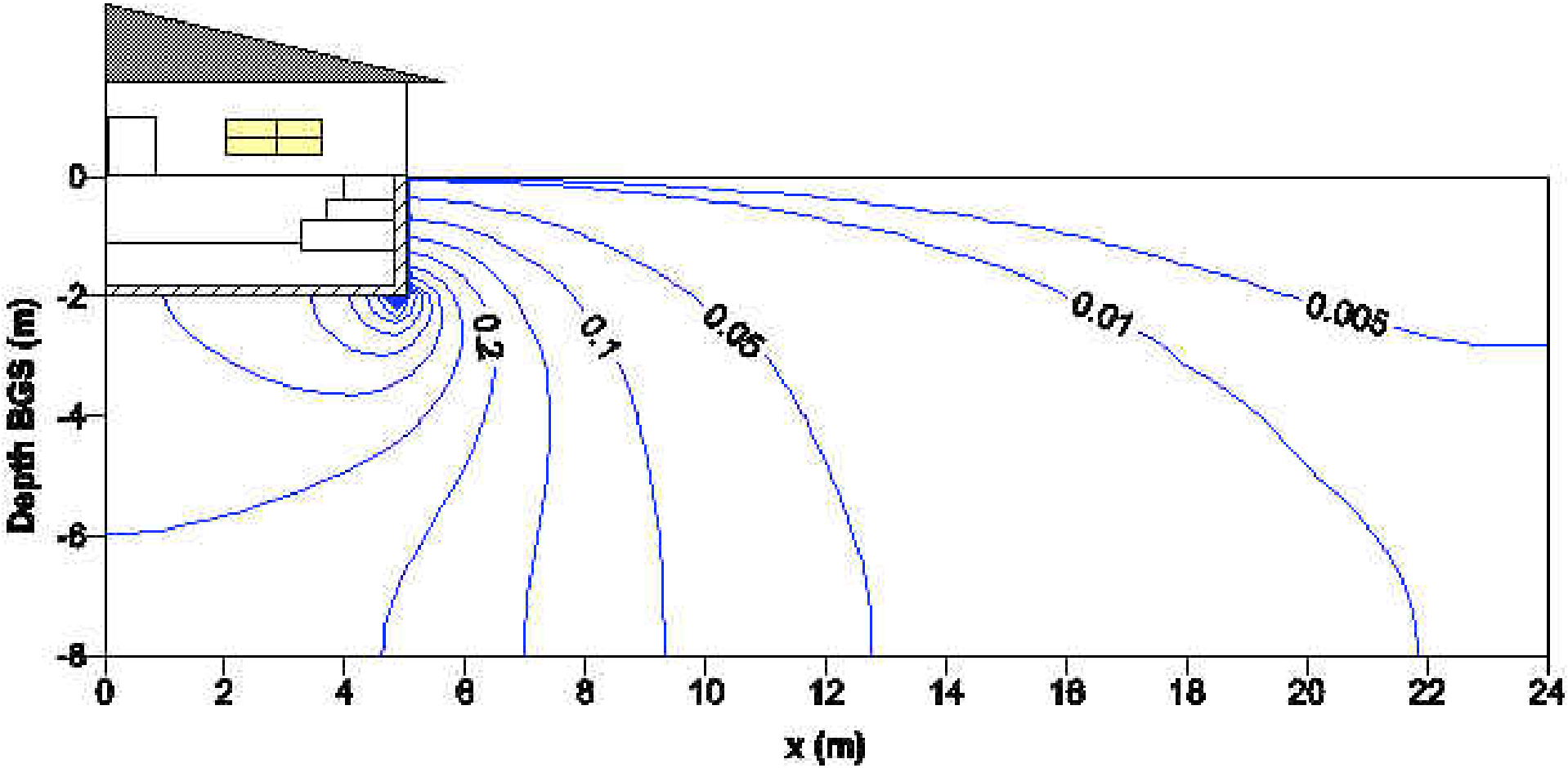
A Few Other Details for Today…



Grid spacing is variable - finer detail near cracks, source boundaries, and domain boundaries

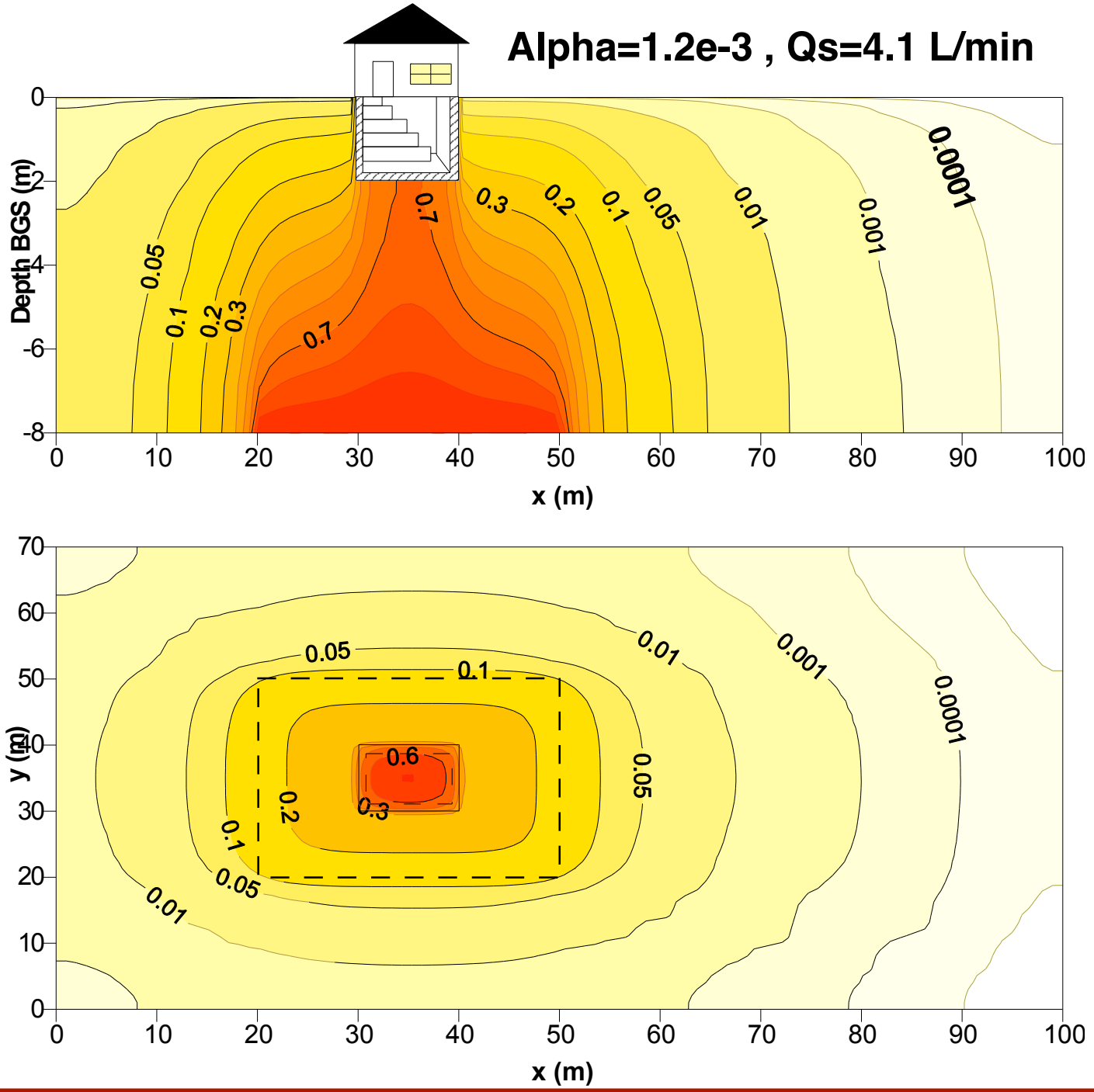
30 m x 30 m constant source (200 mg/L-vapor)

A Sample Pressure Field…



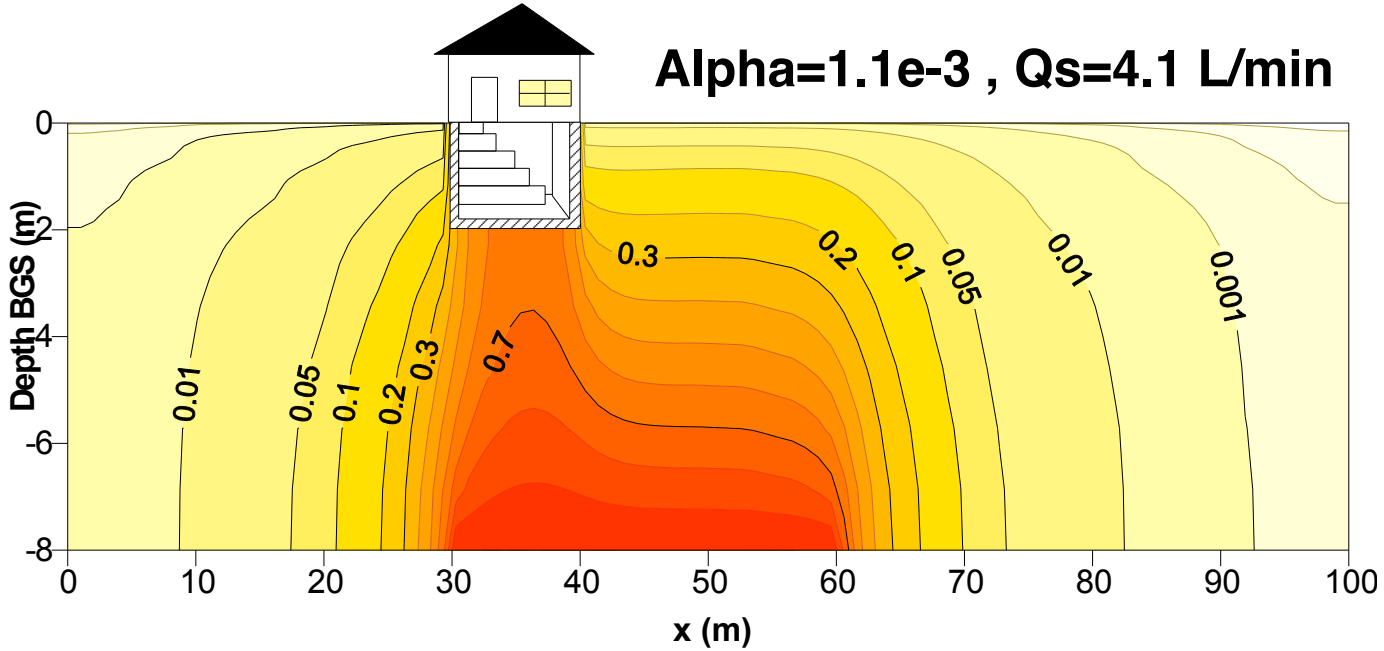
Symmetrical Simulation - cross-section through plane of symmetry

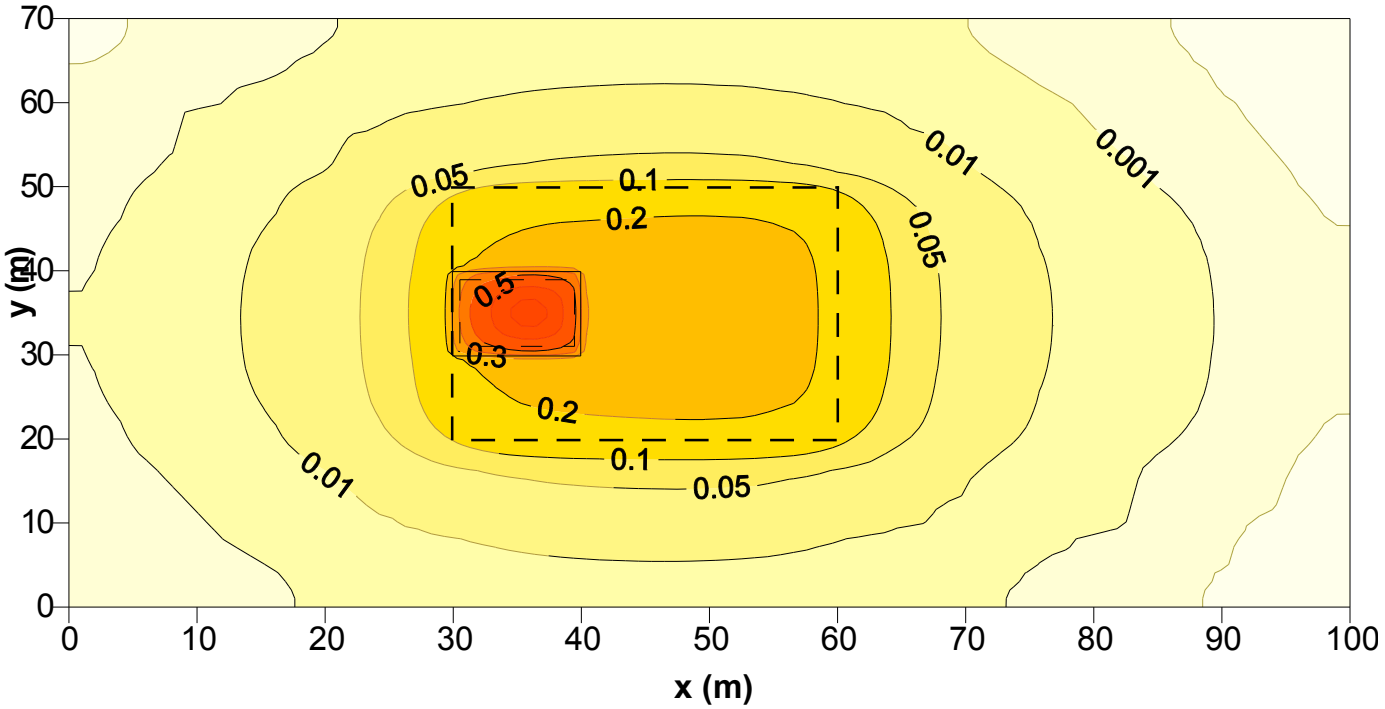
Changes in with Source Position and Depth…



No biodegradation

Changes in with Source Position and Depth…





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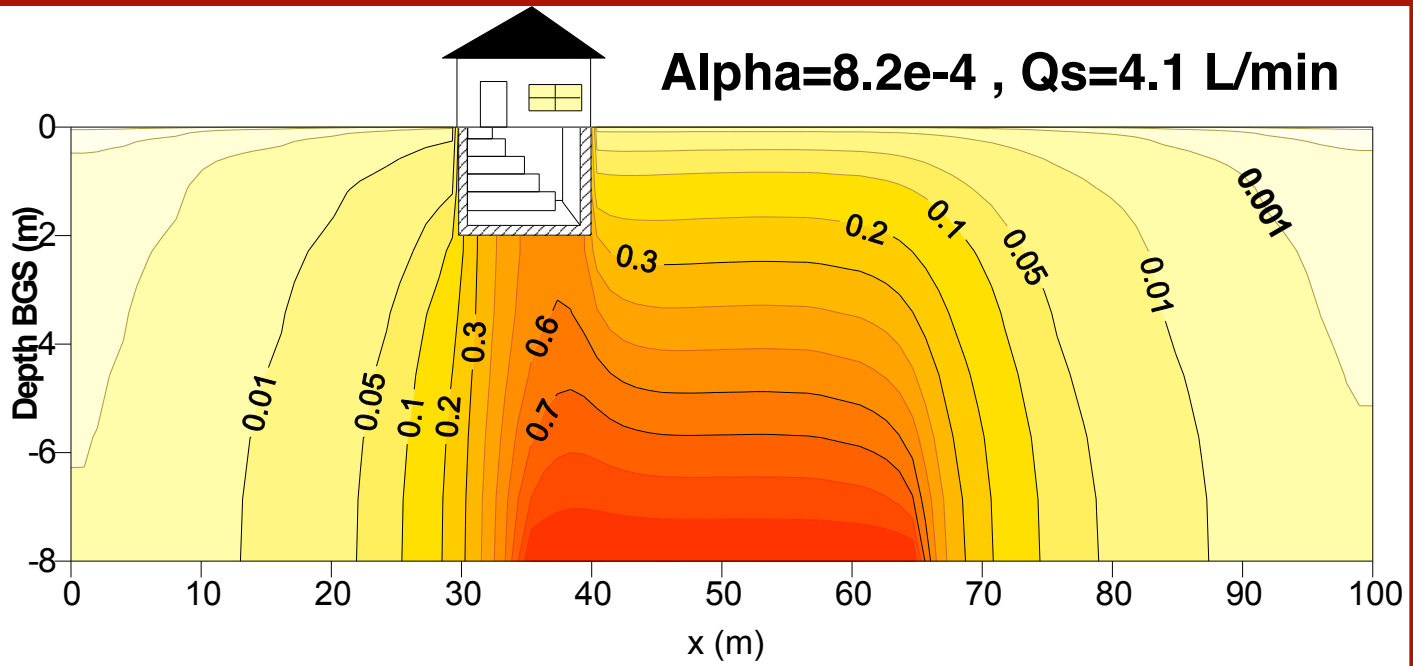

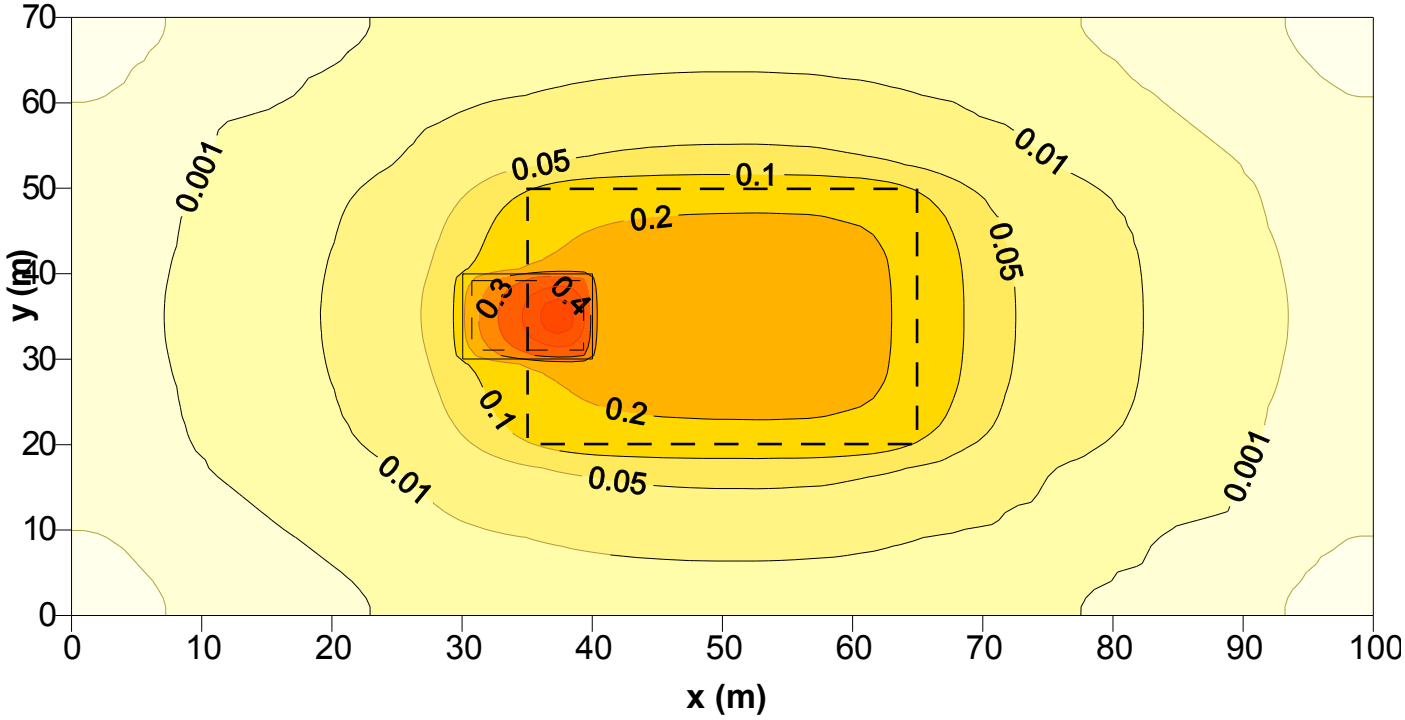

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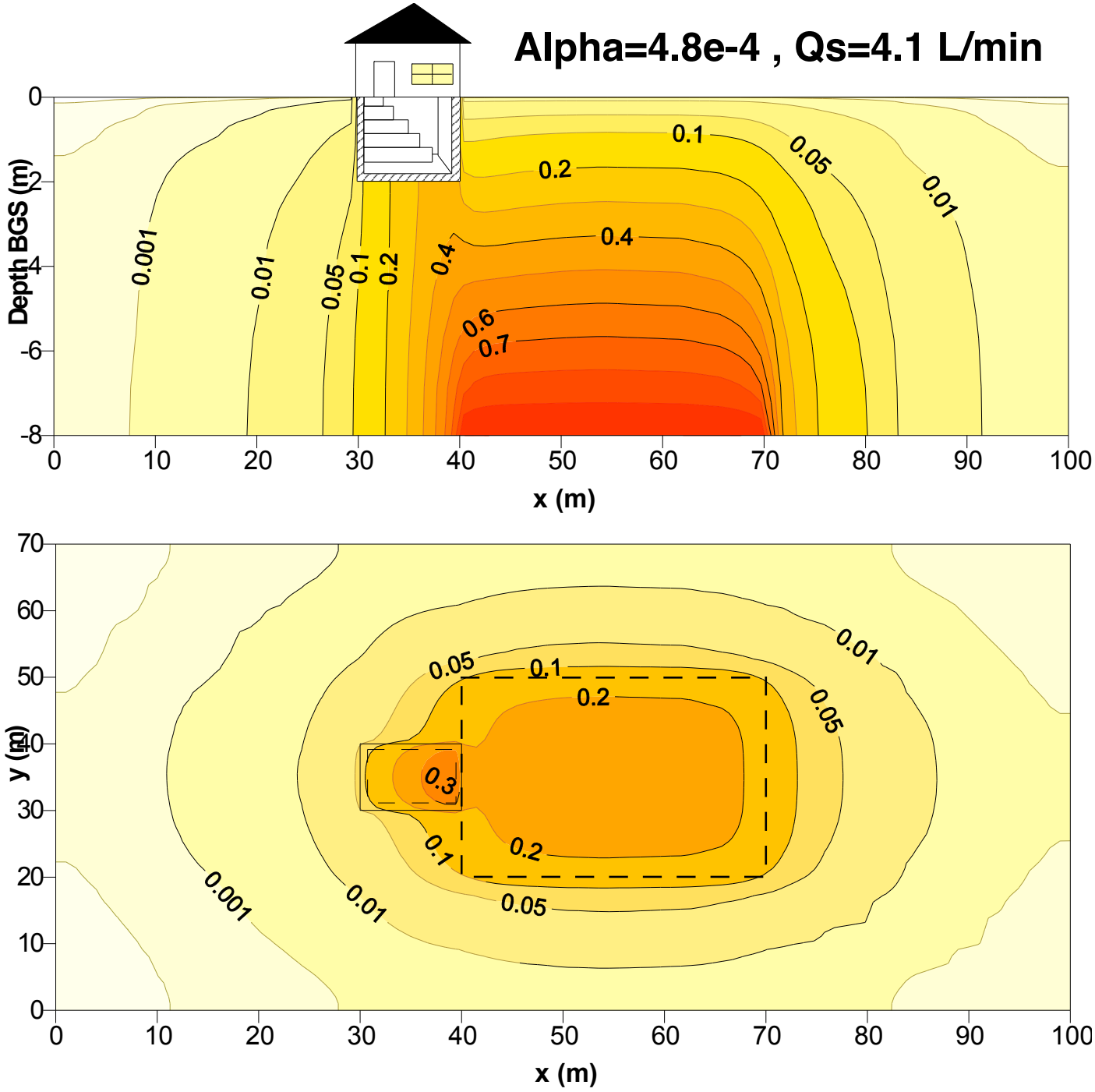

No biodegradation

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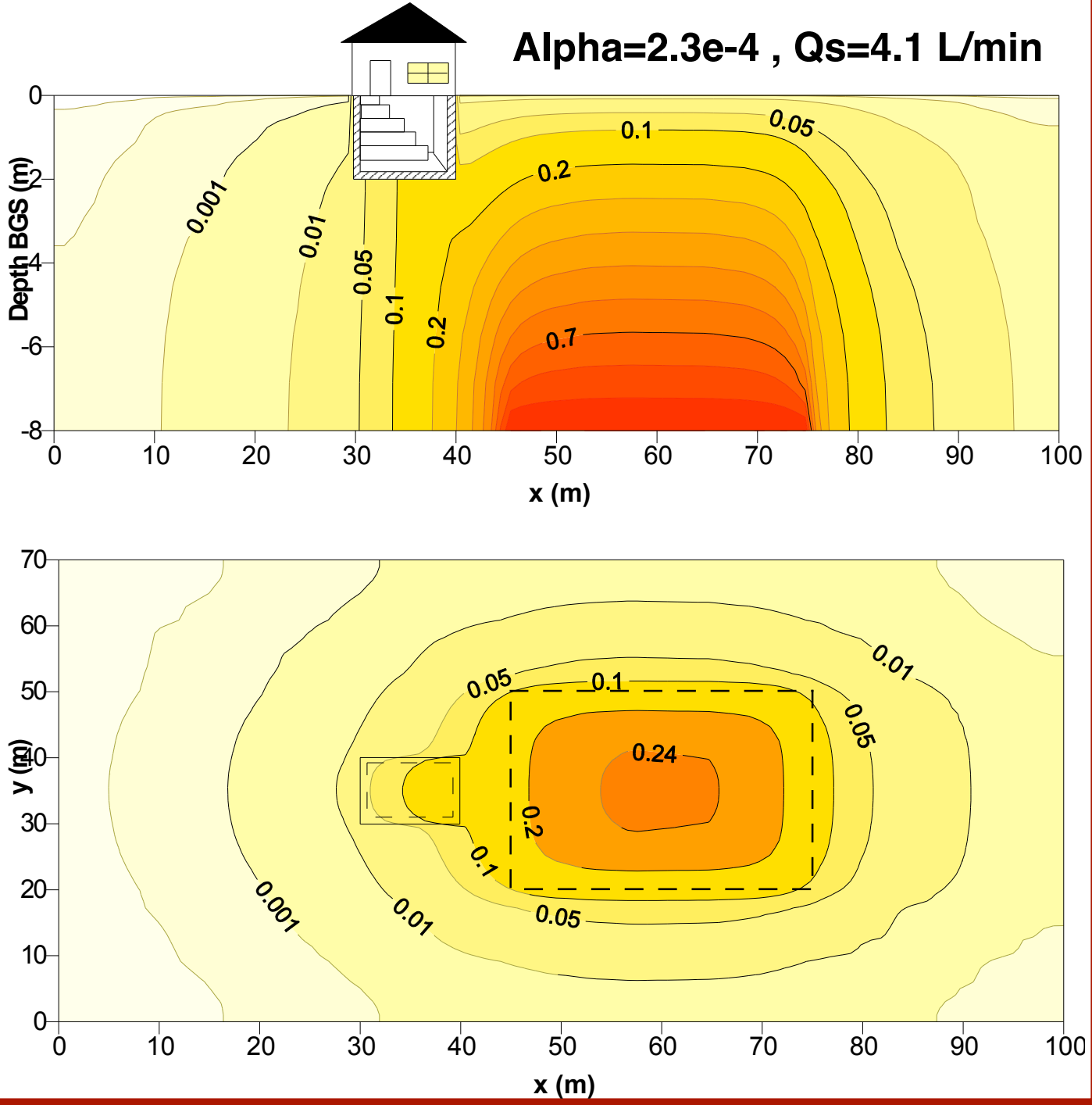

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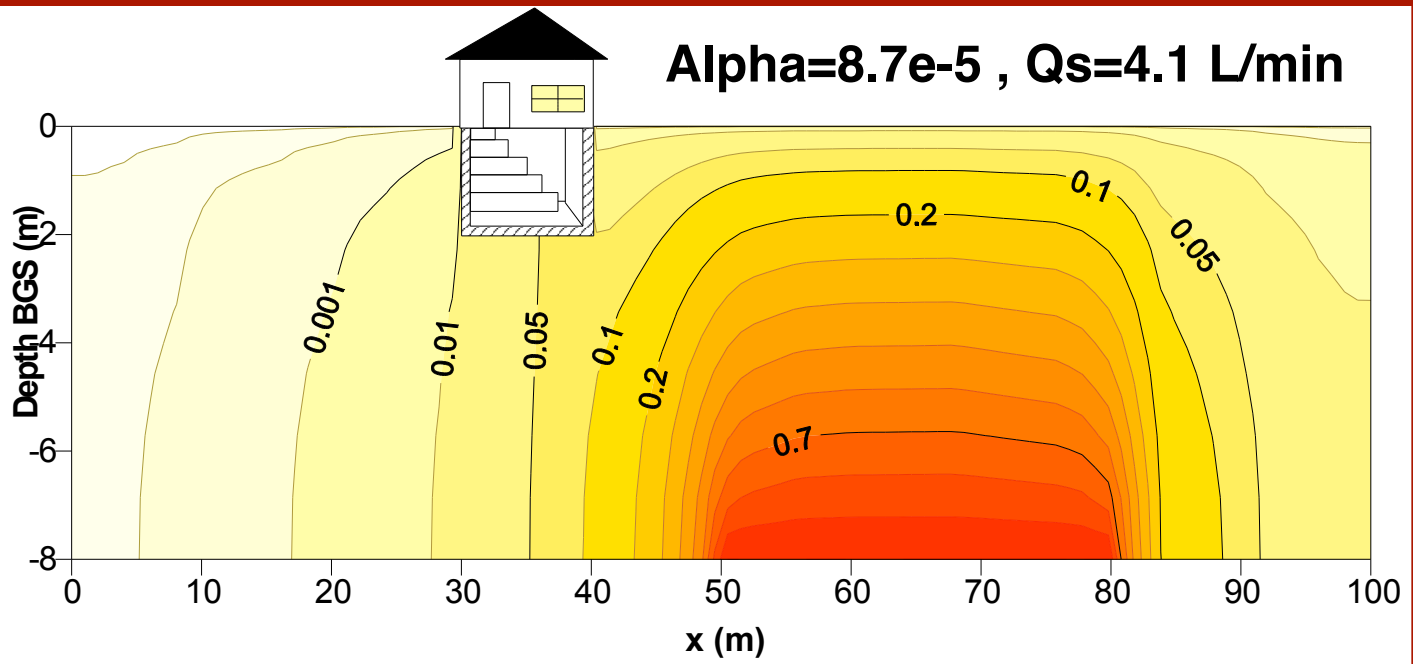
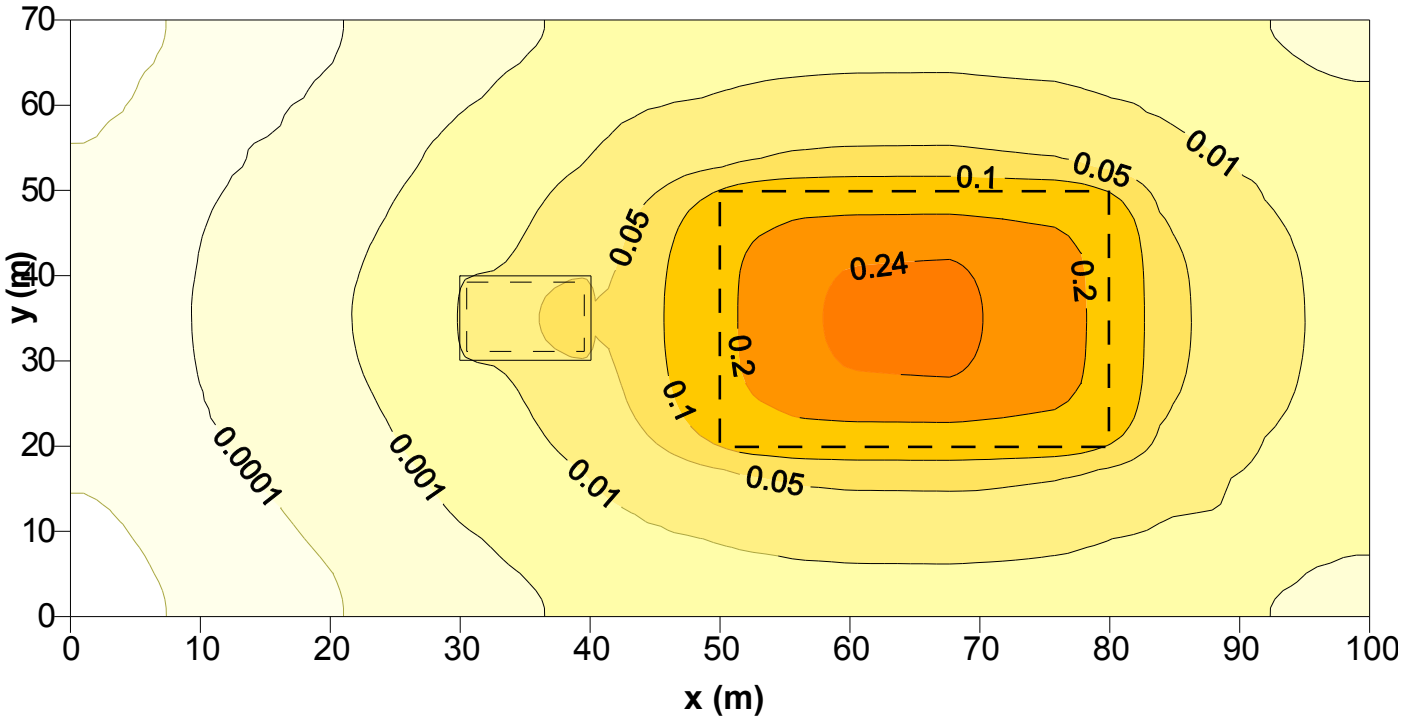
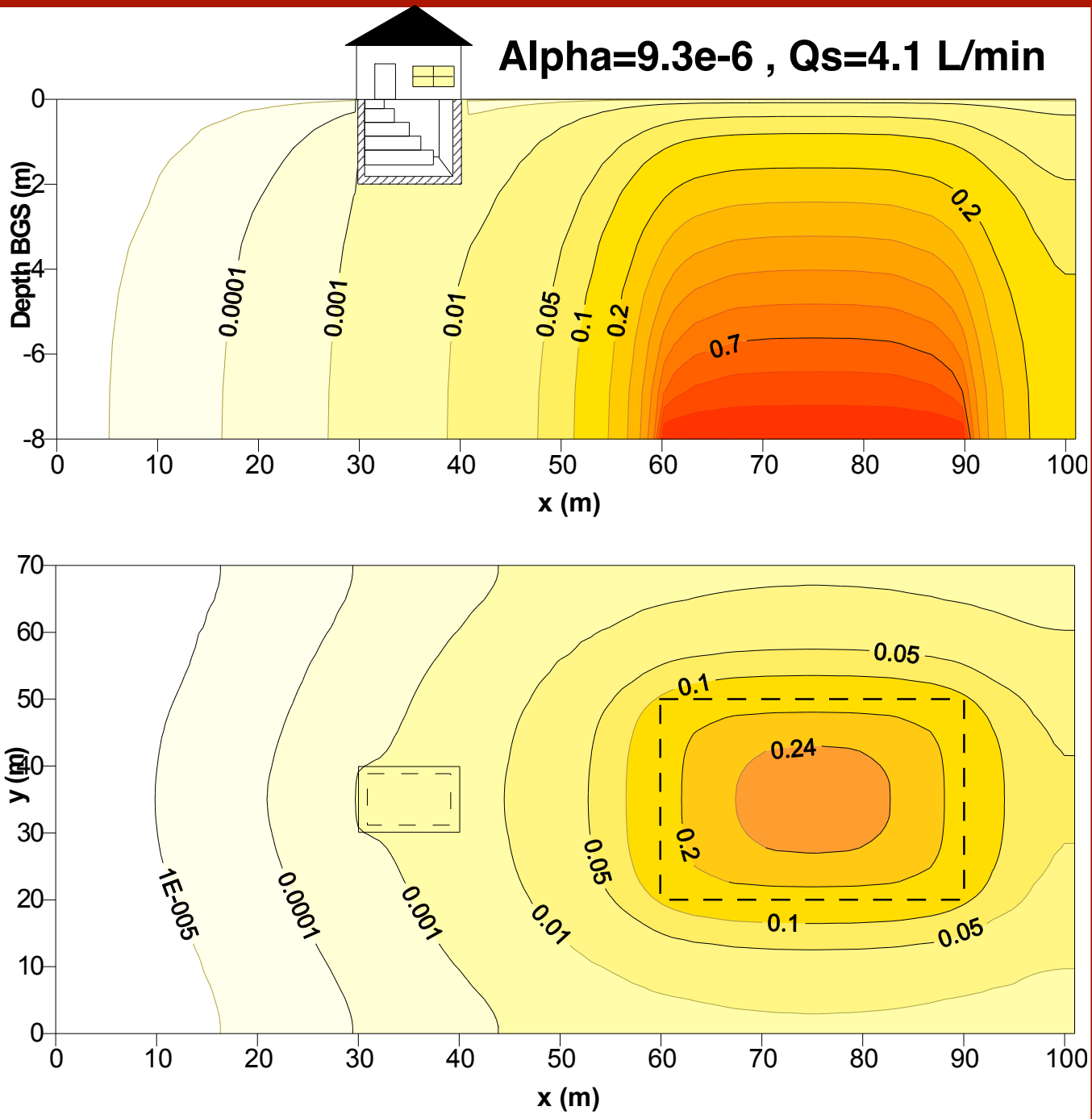




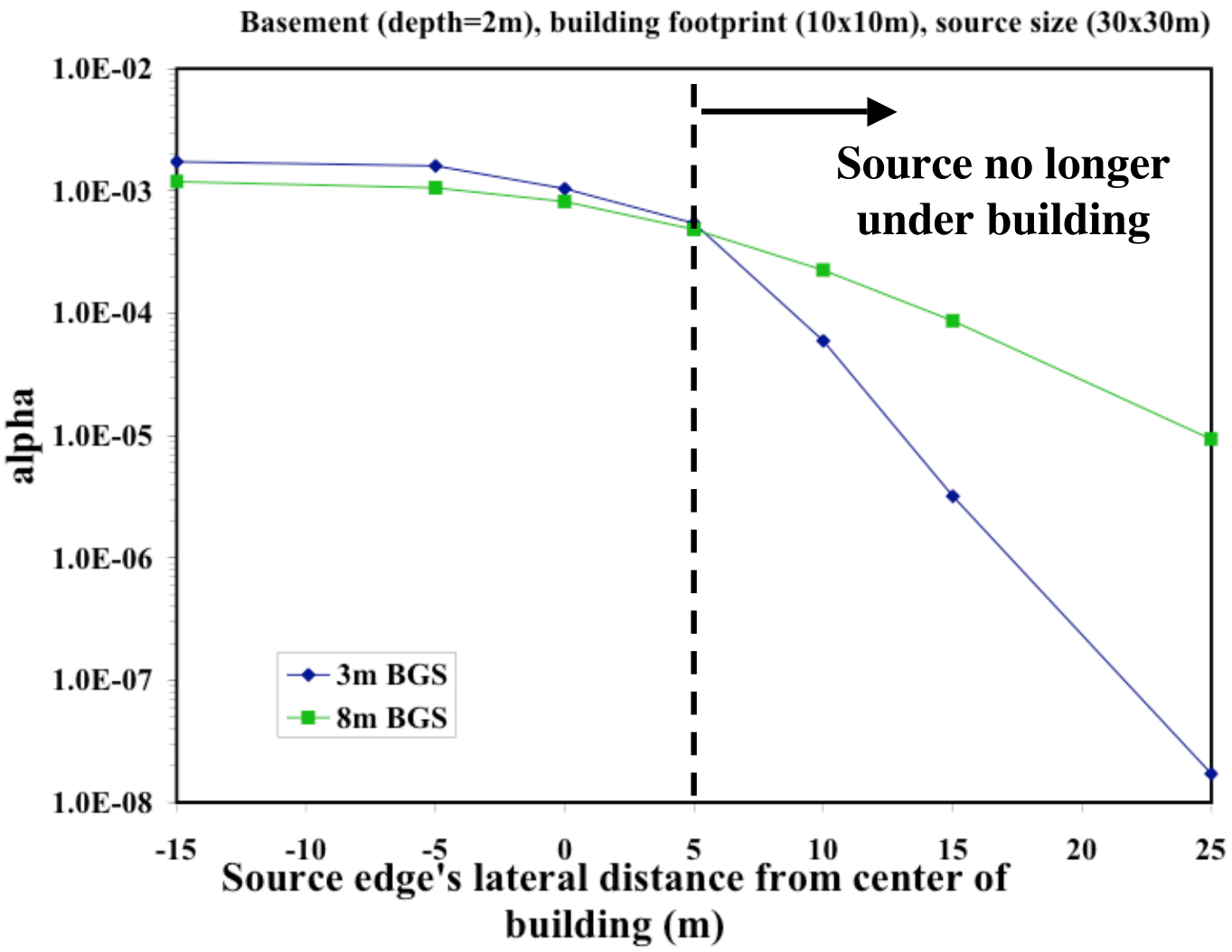
No biodegradation

Changes in with Source Position and Depth…



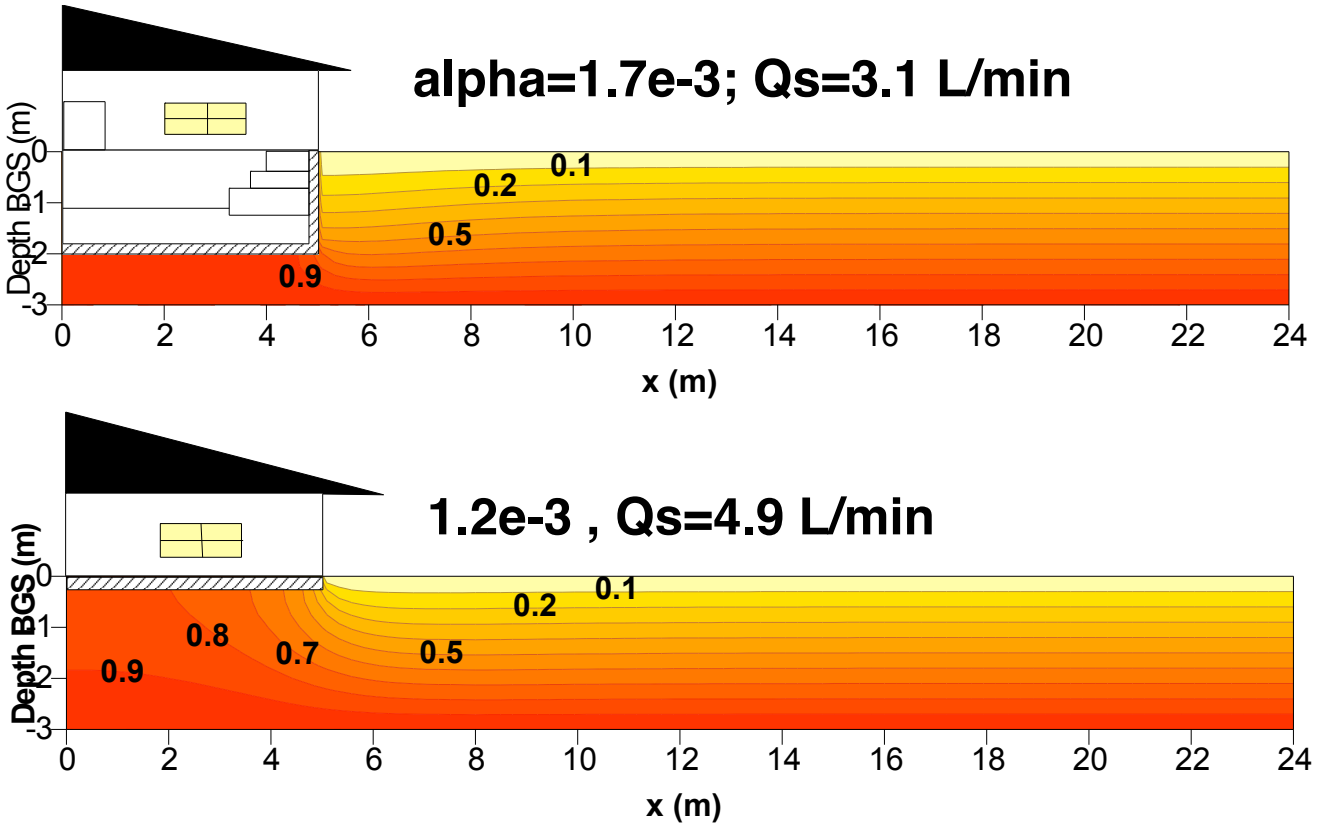
No biodegradation

Changes in with Source Position and Depth…



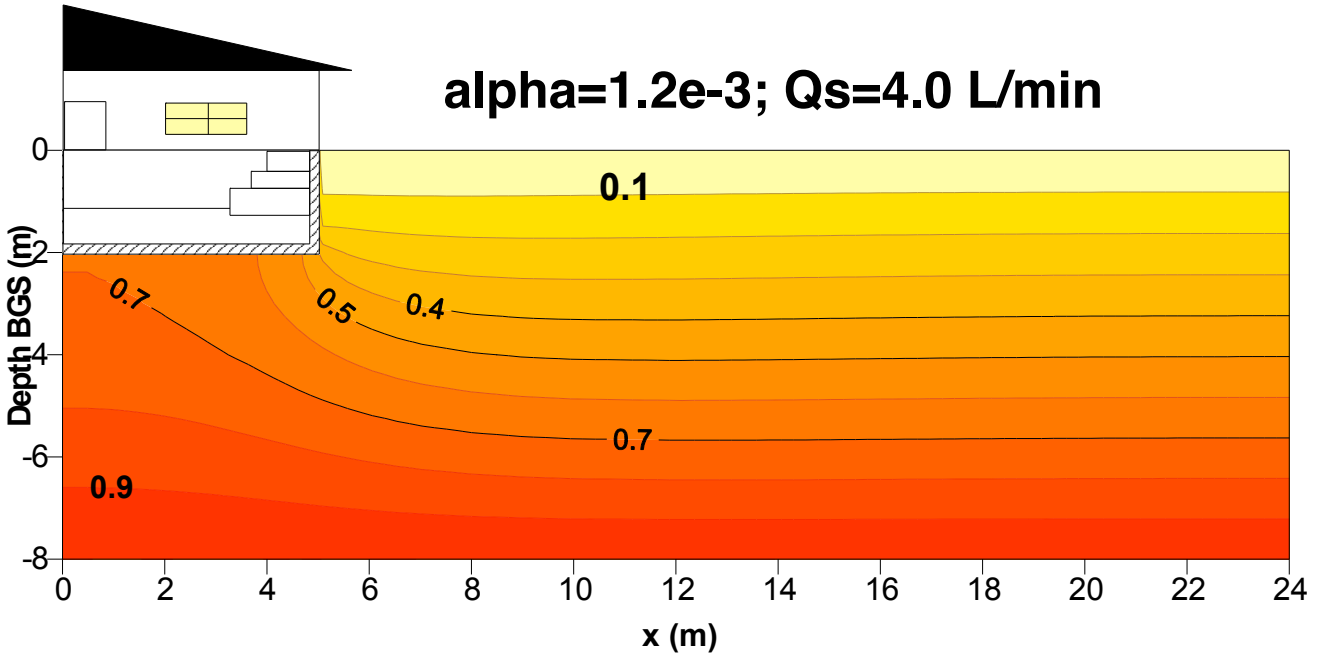
No biodegradation

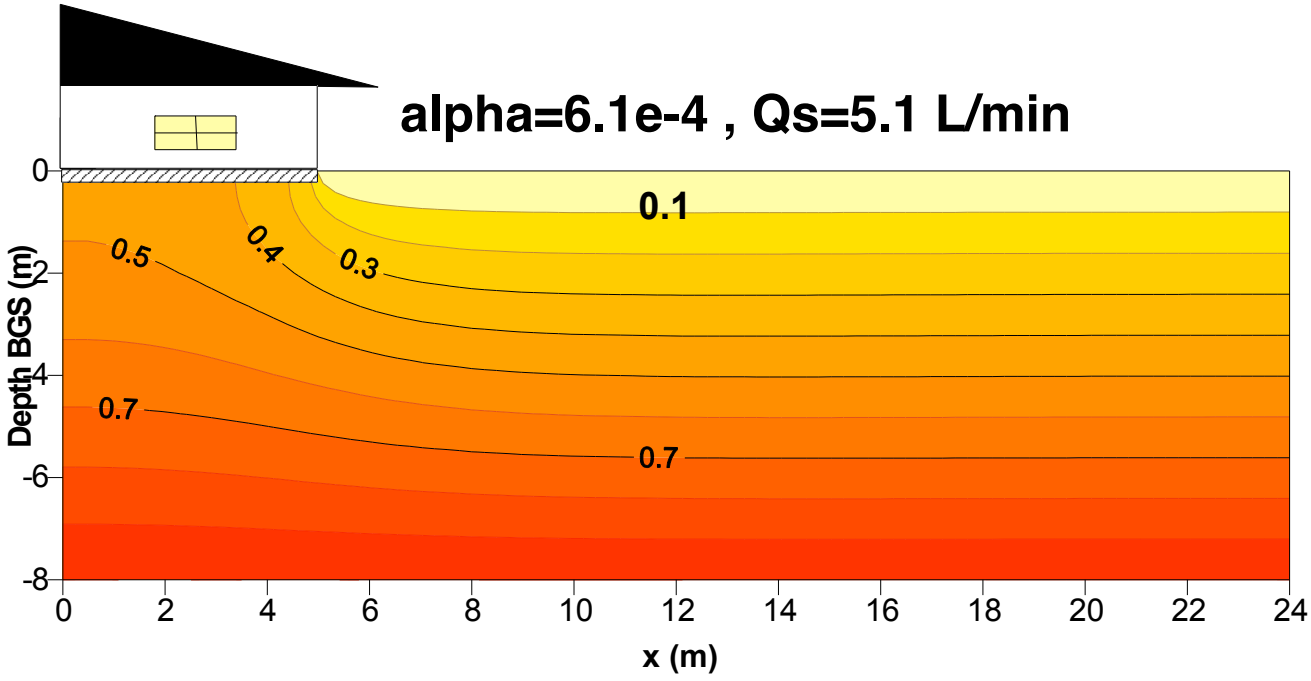
Changes in with Building Cons-truction



No biodegradation

Changes in with Building Cons-truction

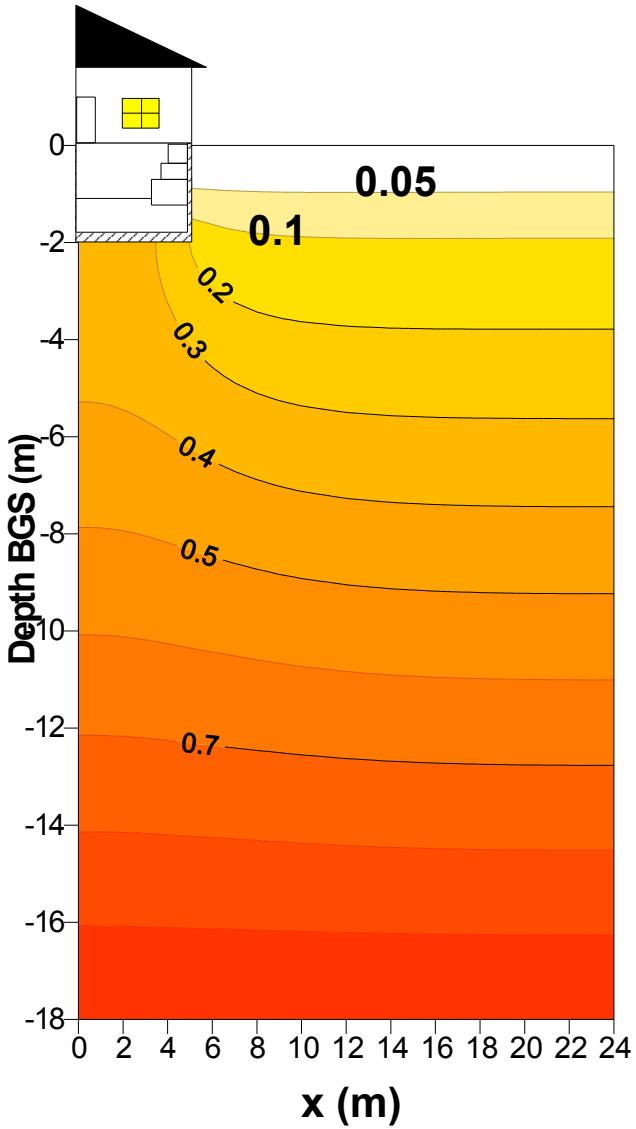




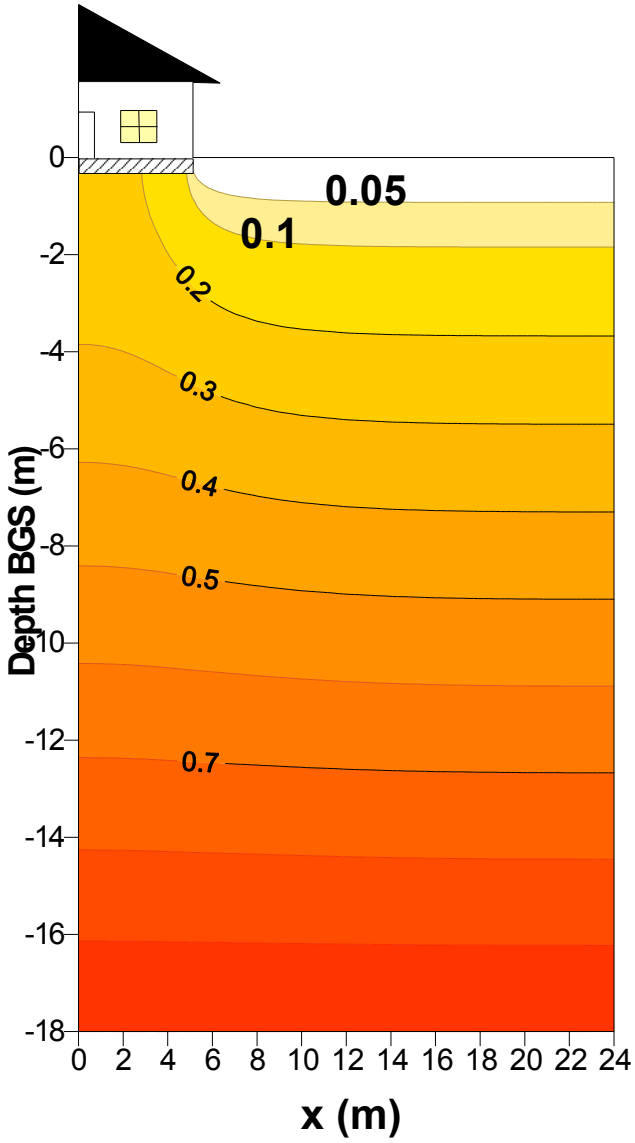
No biodegradation

Changes in with Building Cons-truction

alpha=5.7e-4; Qs=4.1 L/min

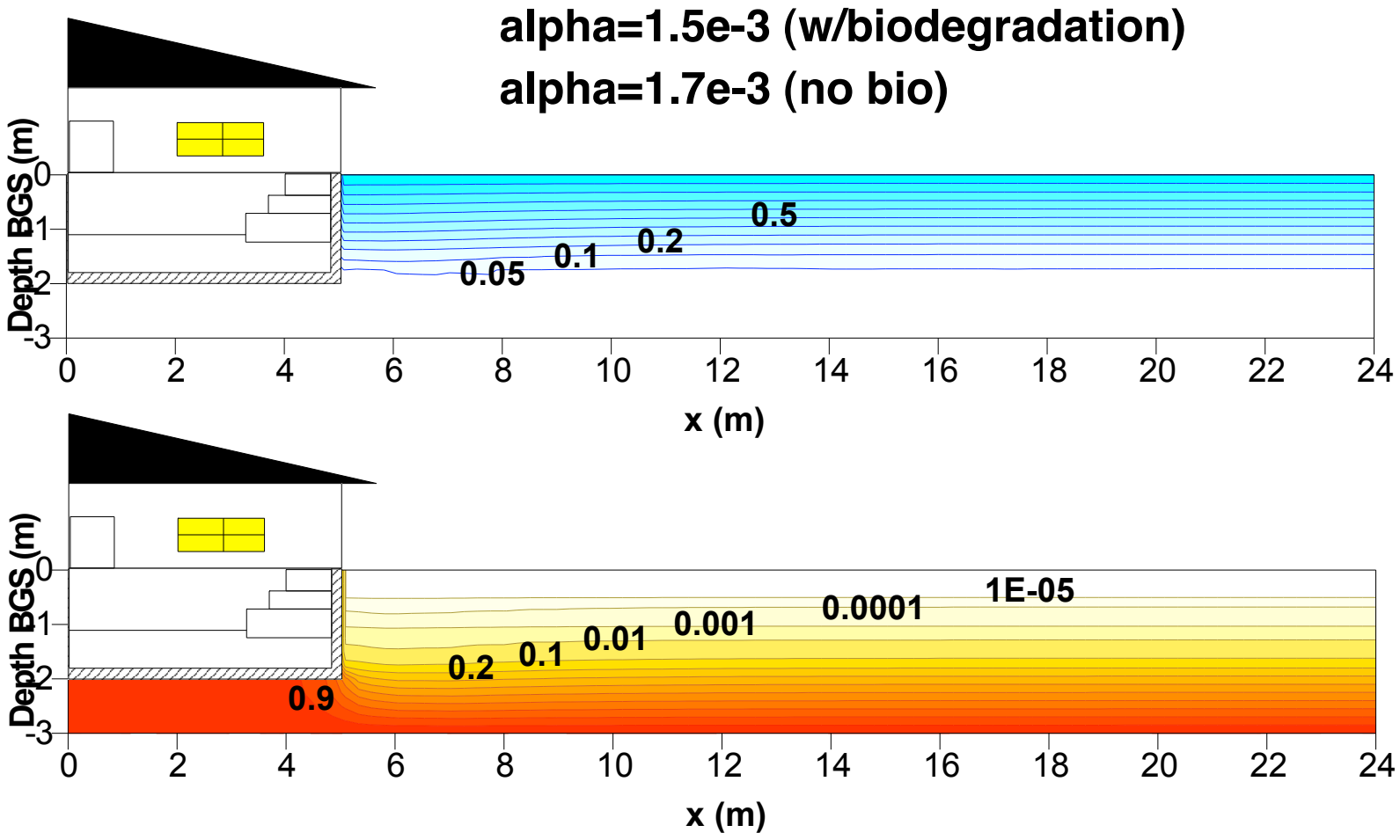


alpha=2.8e-4 , Qs=5.1 L/min

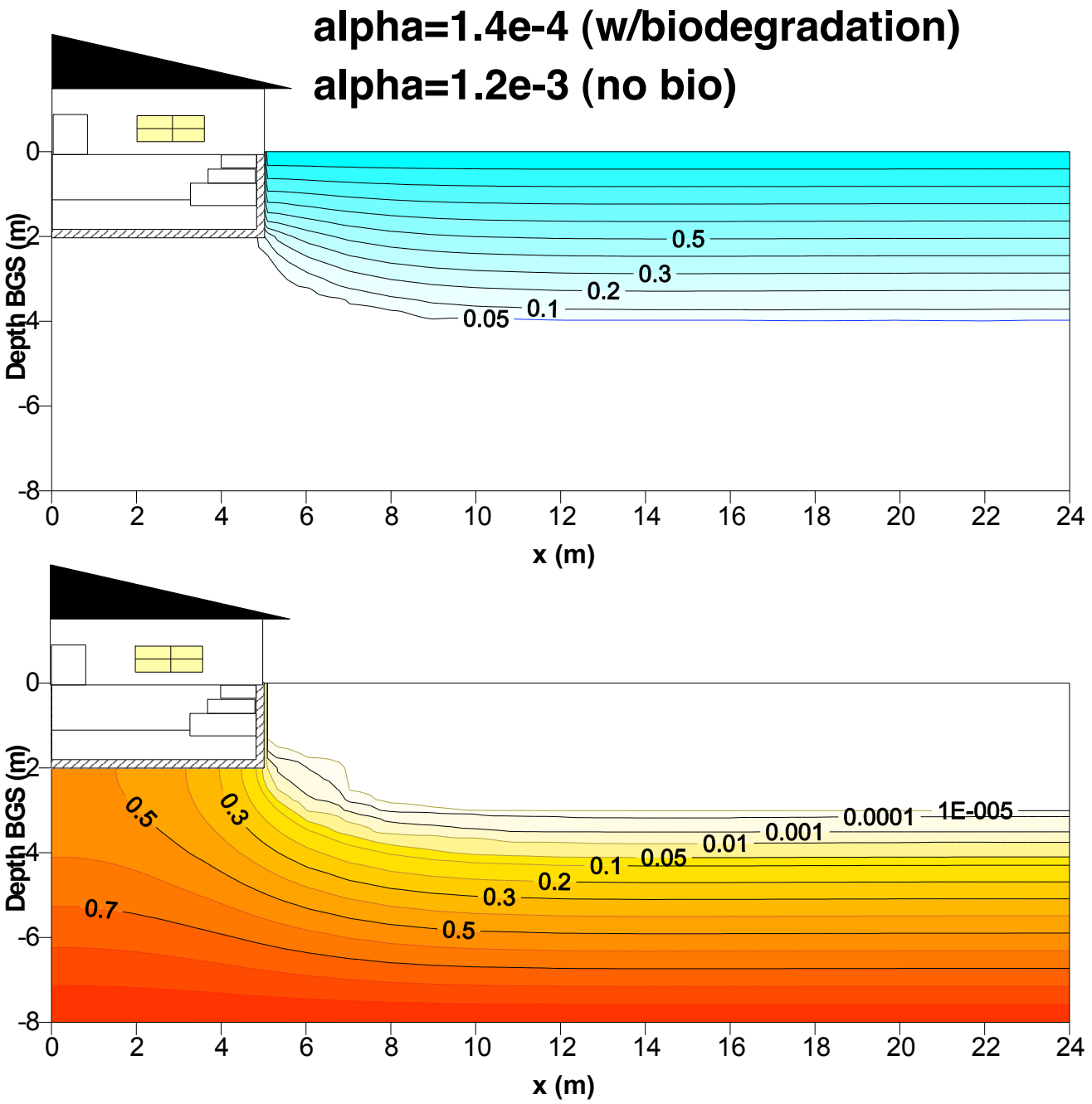


No biodegradation

Changes in with Depth with Bio-decay



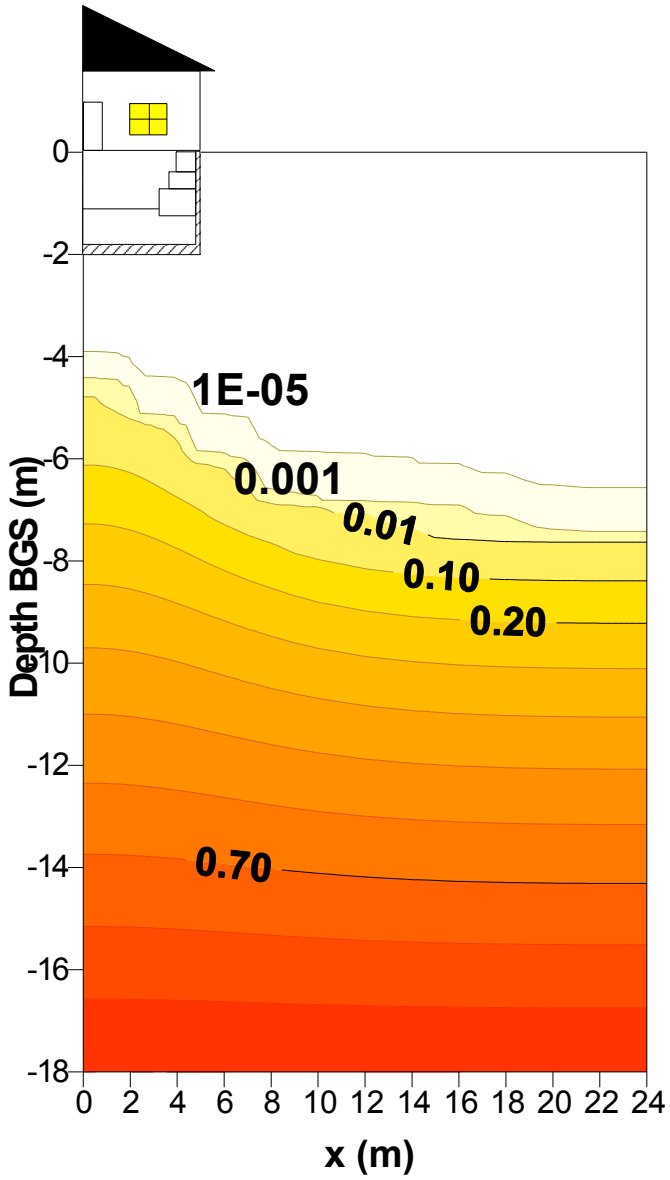
Changes in with Depth with Bio-decay

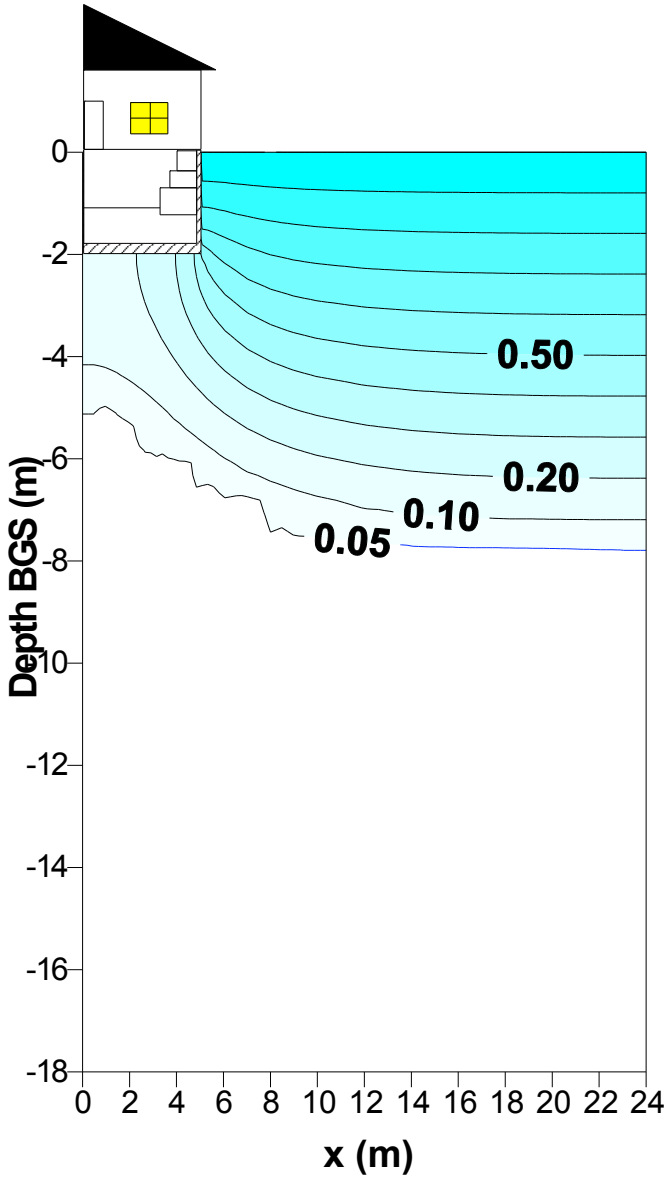


Changes in with Depth with Bio-decay

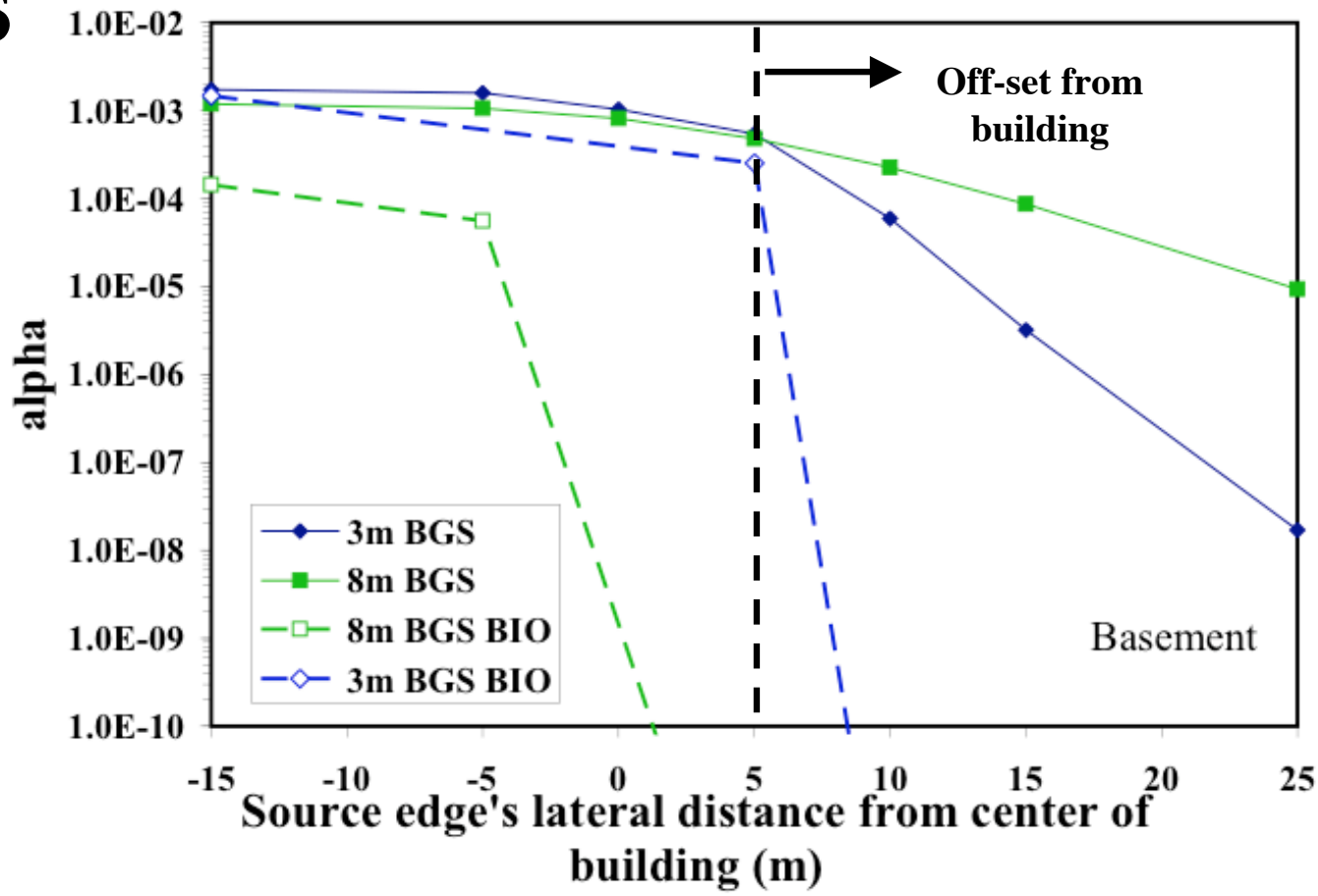
alpha=1.3e-18 (w/biodegradation)

alpha=5.7e-4 (no bio)

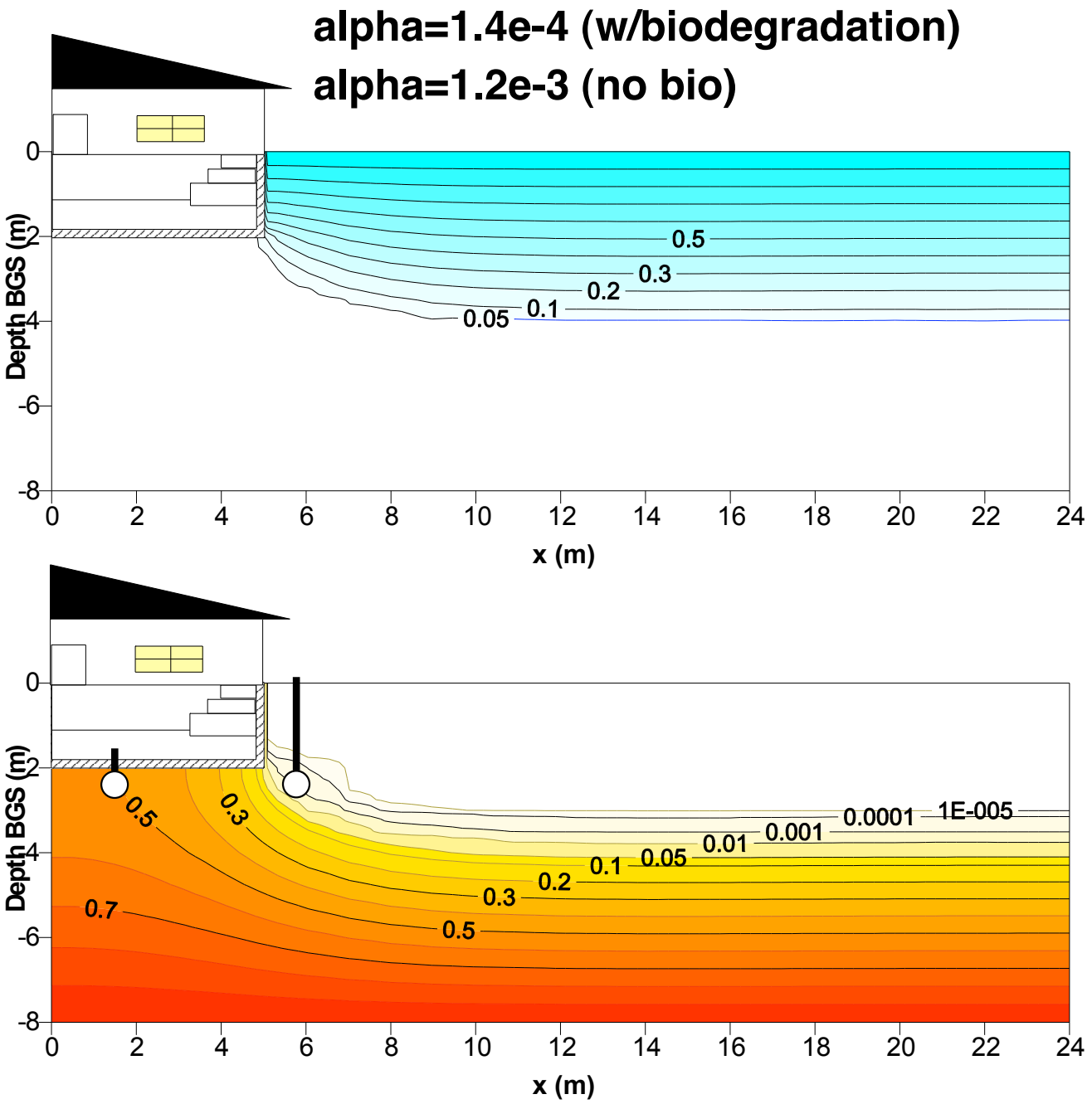




Changes in with Source Position and Depth…

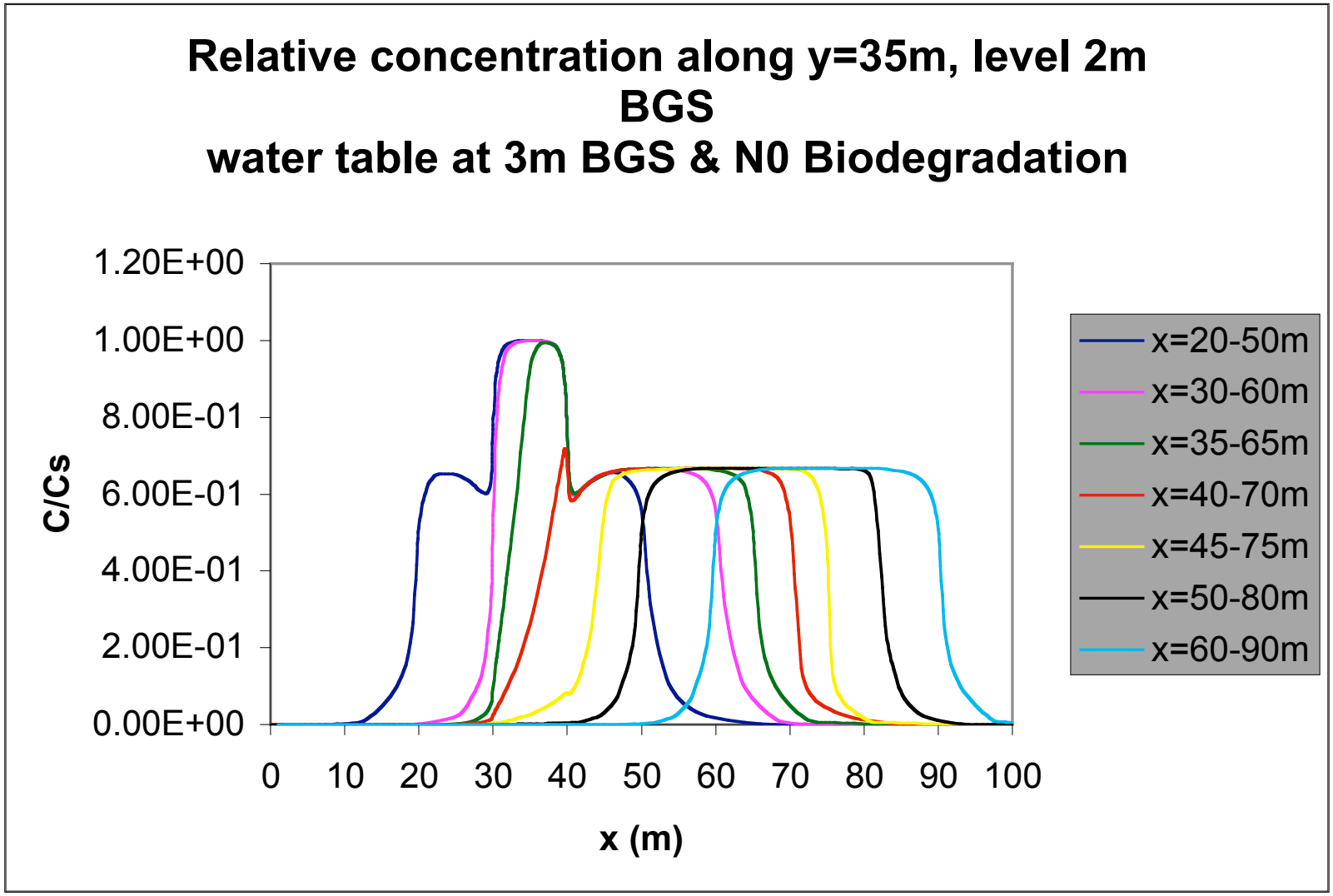


Near-Foundation vs. Through-the-Foundation Sampling?



In Progress…

1. Effect of transient barometric pressure fluctuations?
2. Does alpha correlate better with maximum sub-foundation or near-foundation soil gas concentrations?
3. Effect of source vapor concentration for biodegradation cases?
4. Sensitivity to biodegradation rate input?


Relative concentration along y=35m, level 2m BGS
water table at 3m BGS & N0 Biodegradation
C/Cs
1.20E+00
1.00E+00
8.00E-01
6.00E-01
4.00E-01
2.00E-01
0.00E+00
0
10
20
30
40
50
60
70
80
90
100
x (m)
x=20-50m
x=30-60m
x=35-65m
x=40-70m
x=45-75m
x=50-80m
x=60-90m